O'Malley(1)

STATEMENT TO KING COUNTY COUNCIL and COUNTY EXECUTIVE, February 20, 2014

RE: PROPOSED VASHON TOWN PLAN CHANGES TO ACCOMMODATE AN INDUSTRIAL-SCALE RECREATIONAL MARIJUANA GROWING/PROCESSING AT K2 SITE AND OTHER COMMERCIAL AND INDUSTRIAL SITES ON VASHON/MAURY ISLANDS.

Submitted by Bernie O'Malley, resident of Vashon Island for 24 years.

Preamble: although I was not a supporter of I-502, I accept the persuasive 78% YES vote from Vashon/Maury voters. However I do not believe the YES vote by Island residents suggests an *a priori* agreement now with the changes to the Vashon Town Plan under consideration for Council/Executive vote.

Today I include 3 supporting documents from other authors:

- a research paper produced by a California scientist Evan Mills concerning the little-researched costs of industrial-scale indoor marijuana growing and processing. The study provides extensive references as the basis for the conclusions. The author relies on readily available statistics on the very large markets for medical marijuana in California. For example, 400,000 people are legal and regulated to grow medical marijuana.
- Environmental risks and opportunities in cannabis 2013
- A reprint of a Seattle Times article about Vashon/Maury island agricultural growers. This article supports my view that indoor industrial-scale marijuana is antithetical to how we have chosen to manage our community. The current Vashon Town Plan suits those choices. Any "updates" should be at the direction of the Island community

We ask King County administrators, legislators and Executive to read and thoroughly become familiar with the conclusions drawn in these articles, prior to considering allowing the first large scale indoor marijuana operations to be established in King County.

I have 4objections to the word changes to the Town Plan proposed by County Council to effectively allow *industrial-scale* marijuana to be grown/processed on Vashon/Maury Island:

- **We no longer drive a '56 Ford V8 to the corner store for a newspaper, we don't buy a GMO perfect apple flown here in a 747 in December.**

Times change, we learn new things about our old ways of doing things. Laws changes and we can change. On Vashon/Maury, we already know how to grow outdoors and we'd like to keep that way (Seattle Times). We'd like the rest of King County to follow that lead and reject industrial-scale indoor grows, or at least don't unilaterally impose that on us.

Two years from now, based on the changes the Washington State LQB will need to make once the facts are in, King County and Vashon/Maury Island can lead the way to reject industrial scale projects and support outdoor/greenhouse small-scale.

For example:

a) 1 plant indoors in a 4'x4' space uses the equivalent power of running 30 refrigerators in your garage for several months per plant.
b) 2.2 lbs. of processed marijuana grown indoors is the carbon footprint of 5 trips from LA to NYC driving a Prius. *NOT* counting the carbon footprint of the energy to produce the fertilizer, pipe the water, build the building, build and deliver the equipment and build the Prius.
c) Indoor marijuana production was driven by the previously illegal nature of the business: avoiding law enforcement. Legalization eliminates much of the rationale for indoors.
d) Indoor marijuana was also a method to control quality and production, but indoor and outdoor grown products are now known as equivalent in quality.

If anybody knows about quality, ask our Vashon/Maury Island growers. Indoor marijuana is an outdated energy hog we no longer need or want to be a party to. This isn't NIMBY (not in my back yard). This is ordinary field-smart, common sense.

- ***Why here, Why now, What will this change bring us in 10-20 years.***

The current Vashon Town Plan discusses in detail the Industrial zone at Vashon Center as a necessary part of the modern economy. Vashon/Maury Islands are about 24,000 acres in total area. The Vashon Town Plan limits the amount of Island property allocated to Industrial Zone to about 150 Acres or less, way under 1 % of the total Island acreage. Another 2 % is Neighborhood, Commercial, and Schools zoning. The remaining 97% of the Vashon/Maury Island acreage, including most of the immediate neighborhood around K2, is residential, multi-family, agricultural, or reserves.

If this change in the Vashon Town Plan by the Council/Executive occurs and allows Industrial-scale marijuana as a conditional use, within 10 years we will see many industrial-scale buildings growing/processing marijuana at Vashon Center. I base my projection on statements made by Dan Anglin, the self-described Bakkhus PR man, at his public meeting last week.

Bakkhus is a national company that intends to produce and wholesale to the USA in the next 10 years. He said the cash flowing from just the existing K2 building will easily fund Bakkhus' plan to meet the asserted national need. He estimated 30+ States will very soon see the Colorado cash income from marijuana, will want their own revenue and want to pass their own I-502 process. Then other companies will be enabled to use the 'easy' Vashon community standards to set up shop here.

In short, this King County Council & Executive decision to execute a word change to Vashon Town Plan is ***just the beginning of the process,*** not just an isolated action in a rush-to-judgment decision.

- ***Tell us a good story because nobody actually reads their own Town Plan.***

King County officials including Council member Joe McDermott are quoted to say that the failure to include marijuana growing/processing in the Vashon Town Plan was "mere oversight", to be readily fixed in a simple process. When you read the Vashon Town Plan and its legislated 'overlays' (VS-P30), you'll see the suggested uses envisioned in the 1996 Town Plan as legislated examples of approved Industrial Land Use for Manufacturing processes:

> Food and Kindred Products; Apparel and other Textile Products; Wood Products, Furniture and Fixtures; Printing and Publishing; Fabricated Metal Products; Industrial and Commercial Machinery; Computer and Office Equipment; Electronic and other Electric Equipment; Measuring and Controlling Instruments; Miscellaneous Light Manufacturing; Movie Production/Distribution.

When I compare those approved uses to an industrial scale of manufacturing intoxicants, the 1996 list seems appropriate in scale to Vashon Center and relatively innocuous to me. Conceivably manufacturing "Gummi Bears" or chocolate brownies is a kindred food product but, with 25 mg of a marijuana derivative inserted, the product is an intoxicant and even a medicine to some buyers. If we are discussing industrial scale production of intoxicants or drugs, we should talk a little longer.

The Island citizens in 1996 made well considered choices as appropriate for the Vashon Town Plan. If the community needs to reconsider some additional Land Uses for Vashon Center, or even rezone the K2 building site from Commercial back to Industrial zone, let's do that work in a *measured and very public manner* that respects the previous work of other citizens.

- ***Try to imagine 100 acres of buildings for Industrial-scale manufacturing of marijuana products at Vashon Town Center by 2025.***

Dan Anglin representing Bakkhus/EdenPure was asked at his public meeting on February 13: what will the K2 property look like when operational. He said the existing K2 building will be unmarked and anonymous, no visible signs of what's inside. Then he was asked how Colorado locates similar buildings where the marijuana manufacturing process is more mature. He said Colorado assigns industrial-scale buildings to a specific tightly-zoned area: each marijuana growing/processing building in Colorado was an anonymous, unmarked 'big box' for growing/processing marijuana, sited next to another 'big box' growing/processing marijuana, sited next to another 'big box' growing/processing marijuana, sited next to another 'big box' growing/processing marijuana, etc, etc etc. etc.

This honest and clear answer also accurately describes what you might see in the Kent Valley, on East Marginal Way, in Tukwila, around Boeing/Paine Field, SODO in Seattle. Looking 10 years ahead, try to visualize 10-20 'big box' buildings at Vashon Center on adjacent nearby Commercial/Industrial zoned parcels. Take a ride over to East Marginal Way to see our potential.

Local Island architect Keith Putnam designed K2 in each of its expansions and was introduced as the Bacchus architect. Keith has reported a little known 'secret': *The 18 acres of K2 is actually* ***5*** *legal lots, not just the 11+ building lot and the 6+ vacant lot.*

Wow! Just imagine not 1 K2 building but 5 buildings just on the 18 acre K2 site alone as 'big boxes'. Next imagine the other Industrial-zoned lots with 'big boxes' of marijuana growing/processing. That's my concern for the future. This proposal for a simple change of the Vashon Town Plan is a head fake, a diversion from the real story in our future.

What will that "Simple Word Change" to our Town Plan bring to our small residential community? Think it won't happen here? I think no one will resist the cash.

- **MY CONCLUSION:** **Act in Haste, Regret at Leisure.**

This decision being rushed at Council and the Executive is just the beginning step. Today I ask Joe McDermott and Dow Constantine to stop and think again about the appropriate place for 100 acres of 'big boxes'. This massive change offered to Council and the Executive is unwise in my opinion, but most importantly, a short-sighted use of our neighborhood whether 10 years from now or 100 years from now. We Should Talk About This.

DO NOT DO THIS TO US, Mr. Constantine and Mr. McDermott.

We will suffer the Price of your Haste.

O'Malley (2)

ENERGY UP IN SMOKE

THE CARBON FOOTPRINT OF INDOOR CANNABIS PRODUCTION

Evan Mills, Ph.D.*

April 5, 2011

* The research described in this report was conducted and published independently by the author, a long-time energy analyst and Staff Scientist at the Lawrence Berkeley National Laboratory, University of California. Scott Zeramby provided valuable insights into technology characteristics, equipment configurations, and market factors that influence energy utilization.

The report can be downloaded from: http://evan-mills.com/energy-associates/Indoor.html

On occasion, previously unrecognized spheres of energy use come to light. Important examples include the pervasive air leakage from ductwork in homes, the bourgeoning energy intensity of computer datacenters, and the electricity "leaking" from millions of small power supplies and other equipment. Intensive periods of investigation, technology R&D, and policy development gradually ensue in the wake of these discoveries.

The emergent industry of indoor Cannabis production appears to have joined the list. This report presents a model of the modern-day production process—based on public sources and equipment vendor data—and provides national scoping estimates of the energy use, costs, and greenhouse-gas emissions associated with this activity in the United States.[1]

Large-scale industrialized and highly energy-intensive indoor cultivation of Cannabis is a relatively new phenomenon, driven by criminalization, pursuit of security, and the desire for greater process control and yields.[2,3] The practice occurs in every state,[4] and the 415,000 indoor plants eradicated in 2009[5] represent only the tip of the iceberg.

Aside from sporadic news reports,[6,7] policymakers and consumers possess little information on the energy implications of this practice.[8] Substantially higher electricity demand growth is observed in areas reputed to have extensive indoor Cannabis cultivation. For example, following the legalization of cultivation for medical purposes in California in 1996, Humboldt County experienced a 50% rise in per-capita residential electricity use compared to other areas.[9] Cultivation is today legal in 17 states, albeit not federally sanctioned. In California, 400,000 individuals are authorized to grow Cannabis for personal medical use, or sale to 2,100 dispensaries.[10] Official estimates of total U.S. production varied from 10,000 to 24,000 metric tons per year in 2001,[4] making it the nation's largest crop by value.[11] As of 2006, one third of national indoor production was estimated to occur in California.[12] Based on a rising number of consumers (6.6% of U.S. population above the age of 12),[13] national production in 2011 is estimated for the purposes of this study at 17,000 metric tons, one-third occurring indoors.[14]

Driving the large energy requirements of indoor production facilities are lighting levels matching those found in hospital operating rooms (500-times greater than recommended for reading) and 30 hourly air changes (6-times the rate in high-tech laboratories, and 60-times the rate in a modern home). Resulting electricity intensities are 200 watts per square foot, which is on a par with modern datacenters. Indoor carbon dioxide (CO_2) levels are often raised to four-times natural levels in order to boost plant growth.

Specific energy uses include high-intensity lighting, dehumidification to remove water vapor, space heating during non-illuminated periods and drying, irrigation water pre-heating, generation of CO_2 by burning fossil fuel, and ventilation and air-conditioning to remove waste heat. Substantial energy inefficiencies arise from air cleaning, noise and odor suppression, and inefficient electric generators used to avoid conspicuous utility bills.

Based on these operational factors, the energy requirements to operate a standard production module—a 4x4x8 foot chamber—are approximately 13,000 kWh/year of electricity and 1.5 x 10^6 BTU/year of fossil fuel. A single grow house can contain 10 or more such modules. Power use scales to about 20 TWh/year nationally (including off-grid production and power theft), equivalent to that of 2 million average U.S. homes. This corresponds to 1% of national electricity consumption or 2% of that in households—or the output of 7 large electric power plants.[15] This energy, plus transportation fuel, is valued at $5 billion annually, with associated emissions of 17 million metric tons of CO_2—equivalent to that of 3 million average American cars. (See Figure 1 and Tables 1-5.)

Fuel is used for several purposes, in addition to electricity. Carbon dioxide, generated industrially[16] or by burning propane or natural gas, contributes about 2% to the carbon footprint. Vehicle use for production and distribution contributes about 15% of total emissions, and represents a yearly expenditure of $1 billion. Off-grid diesel- and gasoline-fueled electric generators have emissions burdens that are three- and four-times those of average grid electricity in California. It requires 70 gallons of diesel fuel to produce one indoor Cannabis plant, or 140 gallons with smaller, less-efficient gasoline generators.

In California, the top-producing state, indoor cultivation is responsible for about 3% of all electricity use or 8% of household use, somewhat higher than estimates previously made for British Columbia.[17] This corresponds to the electricity use of 1 million average California homes, greenhouse-gas emissions equal to those from 1 million average cars, and energy expenditures of $3 billion per year. Due to higher electricity prices and cleaner fuels used to make electricity, California incurs 70% of national energy costs but contributes only 20% of national CO_2 emissions from indoor Cannabis cultivation.

From the perspective of individual consumers, a single Cannabis cigarette represents 2 pounds of CO_2 emissions, an amount equal to running a 100-watt light bulb for 17 hours assuming average U.S. electricity emissions (or 30 hours on California's cleaner grid). The emissions associated with one kilogram of processed Cannabis are equivalent to those of driving across country 5 times in a 44-mpg car. One single production module doubles the electricity use of an average U.S. home and triples that of an average California home. The added electricity use is equivalent to running about 30 refrigerators. Producing one kilogram of processed Cannabis results in 3,000 kilograms of CO_2 emissions.

The energy embodied in the production of inputs such as fertilizer, water, equipment, and building materials is not estimated here and should be considered in future assessments.

Minimal information and consideration of energy use, coupled with adaptations for security and privacy, lead to particularly inefficient configurations and correspondingly elevated energy use and greenhouse-gas emissions. If improved practices applicable to commercial agricultural greenhouses are any indication, such large amounts of energy are not required for indoor Cannabis production.[18] Cost-effective efficiency improvements of 75% are conceivable, which would yield energy savings of about $25,000/year for a generic 10-module operation. Shifting cultivation outdoors virtually eliminates energy use (aside from transport), although, when mismanaged, the practice imposes other environmental impacts.[19] Elevated moisture levels associated with indoor cultivation can cause extensive damage to buildings.[20] Electrical fires are an issue as well.[21] For legally sanctioned operations, the application of energy performance standards, efficiency incentives and education, coupled with the enforcement of appropriate construction codes could lay a foundation for public-private partnerships to reduce undesirable impacts.[22] Were compliant operations to receive some form of independent certification and product labeling, environmental impacts could be made visible to otherwise unaware consumers.

* * *

Current indoor Cannabis production and distribution practices result in prodigious energy use, costs, and greenhouse-gas pollution. The hidden growth of electricity demand in this sector confounds energy forecasts and obscures savings from energy efficiency programs and policies. More in-depth analysis and greater transparency in the energy impacts of this practice could improve decision-making by policymakers and consumers alike.

Figure 1. Carbon Footprint of Indoor Cannabis Production

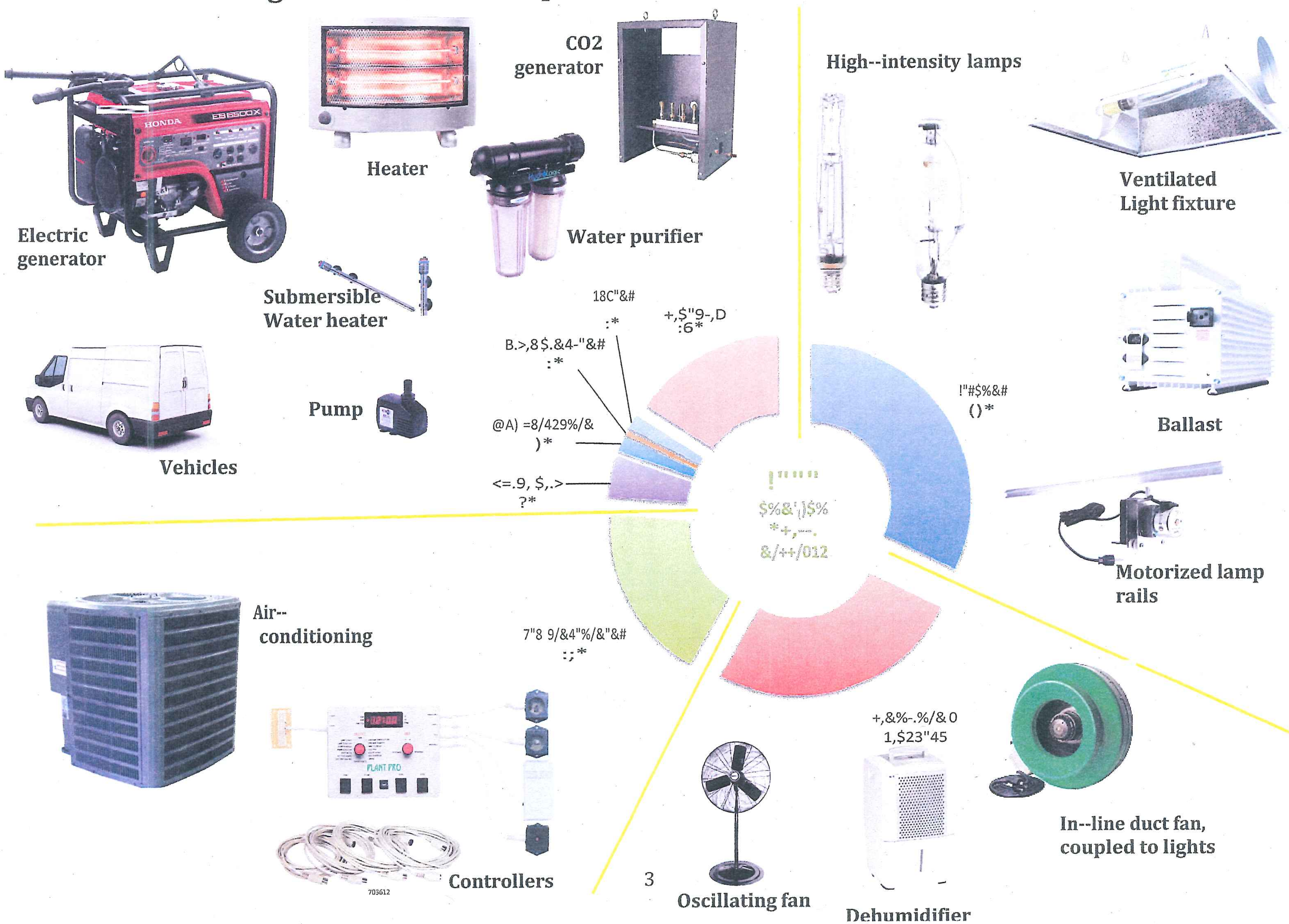

Table 1. Configuration, Environmental Conditions, and Setpoints

Production parameters		
Growing module	16	square feet (excl. walking area)
Number of modules in a room	10	
Area of room	240	square feet
Cycle duration	78	days
Production continuous throughout the year	4.7	cycles
Illumination	*Leaf phase*	*Flowering phase*
Lamp type	Metal halide	High-pressure sodium
Watts/lamp	600	1000
Ballast losses (mix of magnetic & digital)	13%	13%
Lamps per growing module	1	1
Hours/day	18	12
Days/cycle	18	60
Daylighting	none	none
Ventilation		
Ducted luminaires with "sealed" lighting compartment	150	CFM/1000W of light (free flow)
Room ventilation (supply and exhaust fans)	30	ACH
Filtration	Charcoal filters on exhaust; HEPA on supply	
Oscilating fans: per module, while lights on	1	
Water		
Application	40	gallons/room-day
Heating	Electric submersible heaters	
	75	F
Space conditioning		
Indoor setpoint - day	82	F
Indoor setpoint - night	68-70	F
AC efficiency	10.0	SEER
Dehumidification	7x24	hours
CO2 production - target concentration (mostly natural gas combustion in space)	1500	ppm
Electric space heating	when lights off to maintain indoor setpoint	
Target indoor humidity conditions	40-50%	
Fraction of lighting system heat production removed by luminaire ventilation	30%	
Ballast location	Outside conditioned space	
Drying		
Space conditioning, oscillating fans, maintaining 50% RH, 70-80F	7	days
Electricity supply		
grid	85%	
grid-independent generation (mix of diesel, propane, and gasoline)	15%	
Vehicle use		
workers during production	2089	vehicle miles/cycle
wholesale distribution	750	vm/cycle
retail distribution (1 bounce)	3520	vm/cycle

Table 2. Assumptions & conversion factors

Service Levels		
Illuminance*	25-100,000	lux
Airchange rates*	30	changes per hour
Operations		
Cycle duration**	78	days
Cycles/year**	4.7	continuous production
Production module area*	16	square feet (excl. walking area)
Production module volume**	192	cubic feet
Airflow**	96	cubic feet per minute
Modules per room*	10	
Lighting		
Leafing phase		
Lighting on-time*	18	hrs/day
Duration*	18	days/cycle
Flowering phase		
Lighting on-time*	12	hrs/day
Duration*	60	days/cycle
Drying		
Hours/day*	24	hrs
Duration*	7	days/cycle
Equipment		
Average air-conditioning age	5	years
Air conditioner efficiency (SEER)	10	Minimum standard as of 1/2006
Fraction of lighting system heat production removed by luminaire ventilation	30%	
Diesel generator efficiency*	27%	55kW
Propane generator efficiency*	25%	27kW
Gasoline generator efficiency*	15%	5.5kW
Fraction of total prod'n with generators*	15%	
Water use [indoor]*	1	gallons/day-plant
Transportation: Production phase (10 modules)	25	miles roundtrip
Daily service (1 vehicle)	78	trips/cycle. Assume 20% live on site
Biweekly service (2 vehicles)	11	trips/cycle
Harvest (2 vehicles)	10	trips/cycle
Total vehicle miles**	2089	vehicle miles/cycle
Transportation: Distribution		
Amount transported wholesale	5	kg per trip
Mileage (roundtrip)	750	vm/cycle
Retail (0.25oz x 5 miles roundtrip)	3520	vm/cycle
Total**	4270	vm/cycle
Fuel economy, typical car [a]	22	mpg
Annual emissions, typical car [a]	5195	kg CO2
	0.416	kg CO2/mile
Annual emissions, 44-mpg car**	2598	kg CO2
	0.208	kg CO2/mile
Cross-country US mileage	2790	miles

Fuels		
Propane [b]	91,033	BTU/gallon
Diesel [b]	138,690	BTU/gallon
Gasoline [b]	124,238	BTU/gallon
Electric Generation Mix*		
Grid	85%	share
Diesel generators	8%	share
Propane generators	5%	share
Gasoline generators	2%	share
Emissions Factors		
Grid electricity - US [c]	0.609	kgCO2/kWh
Grid electricity - CA [c]	0.384	kgCO2/kWh
Grid electricity - non-CA US [c]	0.648	kgCO2/kWh
Diesel generator**	0.922	kgCO2/kWh
Propane generator**	0.877	kgCO2/kWh
Gasoline generator**	1.533	kgCO2/kWh
Blended generator mix**	0.989	kgCO2/kWh
Blended on/off-grid generation - CA**	0.475	kgCO2/kWh
Blended on/off-grid generation - US**	0.666	kgCO2/kWh
Propane combustion	63.1	kgCO2/MBTU
Prices		
Electricity price - grid (California - PG&E) [d]	$0.390	per kWh (Tier 5)
Electricity price - grid (US, excl. CA) [e]	$0.127	per kWh
Electricity price - off-grid**	$0.390	per kWh
Electricity price - blended on/off - CA**	$0.390	per kWh
Electricity price - blended on/off - US**	$0.166	per kWh
Propane Price [f]	$2.20	per gallon
Gasoline Price - US average [f]	$3.68	per gallon
Diesel Price - US average [f]	$3.98	per gallon
Wholesale price of Cannabis [g]	$4,000	$/kg
Production		
Plants per production module*	4	
Net production per production module [h]	0.7	kg/cycle
US production (2011) [i]	16,974	metric tonnes/y
California production (2011) [i]	5,922	metric tonnes/y
Fraction produced indoors [i]	33%	
US indoor production modules**	1,727,283	
Calif indoor production modules**	602,597	
Cigarettes per kg**	3,000	
Other		
Average new refrigerator	450	kWh/year
	173	kgCO2/year (US average)
Electricity use of a typical US home - 2009 [j]	11,646	kWh/year
Electricity use of a typical California home - 2009 [k]	6,961	kWh/year

* trade and product literature; interviews with equipment vendors
** calculated from other values

Table 3. Carbon footprint of indoor Cannabis Production
(Average US conditions)

	kWh/kg	kgCO2 emissions/kg	
Lighting	1,479	985	32.2%
Ventilation & Dehumid.	1,197	797	26.1%
Air conditioning	827	551	18.0%
Space heat	197	131	4.3%
CO_2 production	54	49	1.6%
Water handling	28	19	0.6%
Drying	73	48	1.6%
Vehicles		479	15.7%
Total	3,855	**3,059**	100.0%

Note: "CO2 production" represents combustion fuel to make on-site CO2. Assumes 15% of electricity is produced in off-grid generators. As the fuels used for CO2 contain moisture, additional dehumidification is required (and allocated here to the CO2 energy row). Air-conditioning associated with CO2 production (as well as for lighting, ventilation, and other incidentals) is counted in the air-conditioning category.

Table 4. Equivalencies								
Indoor Cannabis production consumes...	3%	of California's total electricity, and	8%	of California's household electricity	1%	of total US electricity, and	2%	of US household electricity
U.S. Cannabis production & distribution energy cost...	$5	Billion, and results in the emissions of	17	million tonnes per year of greenhouse gas emissions (CO2)	equal to the emissions of	3	million average cars	
U.S. electricity use for Cannabis production is equivalent to that of...	2	million average US homes						
California Cannabis production and distribution energy cost	$3	Billion, and results in the emissions of	4	million tonnes per year of greenhouse gas emissions (CO2)	equal to the emissions of	1	million average cars	
California electricity use for Cannabis production is equivalent to that of...	1	million average California homes						
A typical 4x4x8-foot production module, accomodating four plants at a time, consumes as much electricity as...	1	average U.S. homes, or	2	average California homes	or	28	average new refrigerators	
Every 1 kilogram of Cannabis produced using national-average grid power results in the emissions of...	2.8	tonnes of CO2	equivalent to	4.9	cross-country trips in a 44mpg car			
Every 1 kilogram of Cannabis produced using a prorated mix of grid and off-grid generators results in the emissions of...	3.1	tonnes of CO2	equivalent to	5.3	cross-country trips in a 44mpg car			
Every 1 kilogram of Cannabis produced using off-grid generators results in the emissions of...	4.3	tonnes of CO2	equivalent to	7.4	cross-country trips in a 44mpg car			
Transportation (wholesale+retail) consumes...	52	gallons of gasoline per kg	or	$1	billion dollars annually, and	479	kilograms of CO2 per kilogram of final product	
One Cannabis cigarette is like driving...	15	miles in a 44mpg car	emitting about	2	pounds of CO2, which is equivalent to operating a 100-watt light bulb for	17	hours	
Of the total wholesale price...	24%	is for energy (at average U.S. prices)						

Table 5. Indicators (Average US conditions)	**per cycle, per production module**	**per year, per production module**	
Energy Use			
Connected Load		3,039	watts/module
Power Density		190	watts/ft2
Elect	2,698	12,626	kWh/module
Fuel to make CO2	0.3	1.5	MBTU
Transportation fuel	37	172	gallons
On-grid results			
Energy cost	592	2,770	$/module
Energy cost		846	$/kg
Fraction of wholesale price		21%	
CO2 emissions	1,988	9,302	kg
CO2 emissions		2,840	kg/kg
Off-grid results (diesel)			
Energy cost	1,196	5,595	$/module
Energy cost		1,708	$/kg
Fraction of wholesale price		43%	
CO2 emissions	3,012	14,094	kg
CO2 emissions		4,303	kgCO2/kg
Blended on/off grid results			
Energy cost	682	3,194	$/module
Energy cost		975	$/kg
Fraction of wholesale price		24%	
CO2 emissions	2,141	10,021	kg
CO2 emissions		3,059	kgCO2/kg
Of which, indoor CO2 production	9	42	kgCO2
Of which, vehicle use			
Fuel use			
During Production		14	gallons/kg
Distribution		39	gallons/kg
Cost			
During Production		$50	$/kg
Distribution		$143	$/kg
Emissions			
During Production		124	kgCO2/kg
Distribution		355	kgCO2/kg

Table 6. Model	Energy type	Penetration	Rating	Number of 4x4x8-foot production modules served	Input energy per module	Units	Hours/day (leaf phase)	Hours/day (flower phase)	Days/cycle (leaf phase)	Days/cycle (flower phase)	kWh / cycle	kWh/year per production module
Light												
Lamps (HPS)	elect	100%	1000	1	1000	W		12		60	720	3,369
Ballasts (losses)	elect	100%	13%	1	130	W		12		60	94	438
Lamps (MH)	elect	100%	600	1	600	W	18		18		194	910
Ballast (losses)	elect	100%	13%	1	78	W	18		18		25	118
Motorized rail motion	elect	5%	5.5	1	0.3	W	18	12	18	60	0	1
Controllers	elect	50%	10	10	1	W	24	24	18	60	2	9
Ventilation and moisture control												
Luminare fans (sealed from conditioned space)	elect	100%	454	10	45	W	18	12	18	60	47	222
Main room fans - supply	elect	100%	242	8.1	30	W	18	12	18	60	31	145
Main room fans - exhaust	elect	100%	242	8.1	30	W	18	12	18	60	31	145
Circulating fans (18")	elect	100%	130	1	130	W	24	24	18	60	242	1,134
Dehumidification	elect	100%	1,035	4	259	W	24	24	18	60	484	2,267
Controllers	elect	50%	10	10	1	W	24	24	18	60	2	9
Spaceheat												
Resistance heat [when lights off]		90%	1,850	10	167	W	6	12	18	60	138	645
Carbon Dioxide												
Parasitic electricity	elect	50%	100	10	5	W	18	12	18	60	5	24
AC (see below)	elect	100%										
In-line heater	elect	5%	115	10	0.6	W	18	12	18	60	1	3
Dehumidification (10% adder)	elect	50%	104	0.4	26	W	18	12	18	60	27	126
Monitor/control	elect	50%	50	10	3	W	24	24	18	60	5	22
Water												
Heating	elect	100%	300	10	30	W	18	12	18	60	19	89
Pumping - irrigation	elect	100%	55	10	5.5	W	1	1	18	60	0	2
Drying												
Dehumidification	elect	75%	1,850	10	139	W		24		7	23	109
Circulating fans	elect	100%	130	5	26	W		24		7	4	20
Heating	elect	75%	1,850	10	139	W		24		7	23	109
Electricity subtotal	elect										2,119	9,918
Air-conditioning											579	2,709
Lighting loads											239	1,117
Loads that can be remoted	elect	100%	1,180	10	118	W					221	1,034
Loads that can't be remoted	elect	100%	450	10	45	W					84	394
CO2-production heat removal	elect	50%	1,118	16.7	34	W	18	12	18	60	35	164
Electricity Total	**elect**				**3,039**	**W**					**2,698**	**12,626**
ON-SITE FUEL	**Units**	**Technology Mix**	**Rating (BTU/ hour)**	**Number of 4x4x8-foot production modules served**	**Input energy per module**		**Hours/day (leaf phase)**	**Hours/day (flower phase)**	**Days/cycle (leaf phase)**	**Days/cycle (flower phase)**	**MBTU or kgCO2/cycle**	**MBTU or kgCO2/year**
On-site CO2 production												
Energy use	propane	45%	11,176	16.7	671	BTU/ho	18	12	18	60	0.3	1.5
CO2 production --> emissions	kg/CO2										20	93
Externally produced Industrial CO2		5%		1	0.011	gallonsCO2/hr	18	12	18	60	1	3
Weighted-average on-site / purchased	kgCO2										2	10
Weighted average on-site / purchased	kg CO2										9	42

Notes for Tables

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[d]. PG&E residential tariff as of 1/1/11, Tier 5 http://www.pge.com/tariffs/ResElecCurrent.xls [Accessed February 5, 2011]. In practice a wide mix of tariffs apply, but the relative shares are not known.

[e]. State-level residential prices, weighted by Cannabis production from [Reference 4], with actual tariffs and U.S. Energy Information Administration, "Average Retail Price of Electricity to Ultimate Customers by End-Use Sector, by State," http://www.eia.doe.gov/electricity/epm/table5_6_a.html [Accessed February 7, 2011]

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[i]. See Reference 14 for derivation.

[j]. Total U.S. Electricity Sales: U.S. Energy Information Administration, "Retail Sales of Electricity to Ultimate Customers: Total by End-Use Sector" http://www.eia.gov/cneaf/electricity/epm/table5_1.html [Accessed March 5, 2011]

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1. This report presents a model of typical production methodologies and associated transportation energy use. Data sources include equipment manufacturer data, trade media, the open literature, and interviews with horticultural supply vendors. All assumptions used in the analysis are presented in Table 2. The resultant normalized (per-kilogram) energy intensity is driven by the target environmental conditions, production process, and equipment efficiencies. While less energy-intensive processes are possible (either with lower per-unit-area yields or more efficient equipment and controls), much more energy-intensive scenarios are also possible (e.g., rooms using 100% recirculated air with reheat, hydroponics, and loads not counted here such as well-water pumps and water purification systems). The assumptions about vehicle energy use are likely conservative, given the longer-range transportation associated with interstate distribution. Some localities (very cold and very hot climates) will see much larger shares of production indoors, and have higher space-conditioning energy demands than the typical conditions assumed here. Some authors [See Plecas, D. J. Diplock, L. Garis, B. Carlisle, P. Neal, and S. Landry. *Journal of Criminal Justice Research,* Vol. 1 No 2., p. 1-12.] suggest that the assumption of 0.75kg yield per production module per cycle is an over-estimate. Were that the case, the energy and emissions values in this report would be even higher, which is hard to conceive. Additional key uncertainties are total production and the indoor fraction of total production (see note 14), and the corresponding scaling up of relatively well-understood intensities of energy use per unit of production to state or national levels by weight of final product. Greenhouse-gas emissions estimates are in turn sensitive to the assumed mix of on- and off-grid power production technologies and fuels, as off-grid production tends to have substantially higher emissions per kilowatt-hour than grid power. Costs are a direct function of the aforementioned factors, combined with electricity tariffs, which vary widely across the country and among customer classes. More in-depth analyses could explore the variations introduced by geography and climate, alternate technology configurations, and production techniques.
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it under-estimates the electrical demand and applies energy prices that fall far short of the inclining marginal-cost tariff structures applicable in many states, particularly California.

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12. See Gettman, *op cit.*, at ref 4.

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14. Total Production: The only official domestic estimate of U.S. Cannabis production was 10,000 to 24,000 tonnes for the year 2001. Gettman (*op cit.*, at ref. 4) conservatively retained the lower value for the year 2006. This 2006 base is adjusted to 2011 values using 10.9%/year net increase in number of consumers between 2007 and 2009, per U.S. Department of Health and Human Services (*op cit.*, at ref. 12). The result is approximately 17 million tonnes of total production annually (indoor and outdoor). Indoor Share of Total Production: The three-fold changes in potency over the past two decades, reported by federal sources, are attributed at least in part to the shift towards indoor cultivation [See http://www.justice.gov/ndic/pubs37/37035/national.htm and Hudson *op cit.*, at ref 4]. A weighted-average potency of 10% THC (U.S. Office of Drug Control Policy. 2010. "Marijuana: Know the Facts"), reconciled with assumed 7.5% potency for outdoor production and 15% for indoor production implies 33.3%::67.7% indoor::outdoor production shares. For reference, as of 2008, 6% of eradicated plants were from indoor operations, which are more difficult to detect than outdoor operations. A 33% indoor share, combined with per-plant yields from Table 2, would correspond to a 4% eradication success rate for the levels reported (415,000 indoor plants eradicated in 2009) by the DEA (*op cit.*, at ref 5). Assuming 400,000 members of medical Cannabis dispensaries in California (each of which is permitted to cultivate), and 50% of these producing in the generic 10-module room assumed in this analysis, output would slightly exceed this study's estimate of total statewide production. In practice, significant indoor production is no doubt conducted outside of the medical marijuana system.

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O'Malley 3

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Analysis Corporation

Environmental Risks and Opportunities in Cannabis Cultivation

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BACK OF THE ENVELOPE CALCULATIONS

Table of Contents

Executive Summary

The most important environmental cost of marijuana production (cultivation of cannabis) in the legal Washington market is likely to stem from energy consumption for indoor, and to a lesser extent, greenhouse, growing. Nearly all of this energy is electricity used for lighting and ventilating, and the energy bill can amount to 1/3 of production costs. While the price of electricity provides growers a market signal for efficient production, it does not reflect the climate effect of greenhouse gas released by electricity production nor other "externalities"—the value of environmental and other harms that are not included in the price of goods.

Though electricity in the Pacific Northwest is some of the lowest-GHG-intensity in the US, growing cannabis could still have a significant "carbon footprint." Marginal electricity consumption (in addition to current levels) is much more carbon-intensive than average consumption in the region, since daily peaks are usually met with natural-gas fired generation rather than less GHG-intensive "baseload" hydropower generation. Increased cannabis cultivation indoors will likely be a noticeable fraction (single-digit percentages) of the state's total electricity consumption. Indoor cultivation that concentrates lighting in off-peak electricity periods at night will have a much smaller climate effect than if lighting is provided during peak electric use times. Greenhouse production requires much less energy, and for outdoor cultivation energy is an insignificant fraction of production costs.

Other environmental effects of cannabis are also worth attention, including water use, fertilizer greenhouse-gas emissions, and chemical releases, but are typical of similar horticultural and agricultural operations and should not be primary concerns of the Liquor Control Board (LCB). Even the climate effects are much less important than some other risks (and benefits) of a legal cannabis market. They should be mitigated *when that can be done without substantial sacrifice of other goals*, as appears to be the case.

Policies available to the LCB to respond to environmental concerns include adjusting the excise tax on indoor-cultivated marijuana to reflect about 9c per gram worth of global warming impact, labeling low-GHG marijuana as such, encouraging efficient LED lighting development and use, allowing outdoor cultivation, making energy-efficient production a condition of licensing, and leading other state agencies in the development of better technologies and diffusion of best practices to growers. If legal cannabis production moves toward national acceptance, the importance of developing environmentally sound production practices will grow, and policies made now in Washington and Colorado, the early adopters, may shape practices in the new industry nationwide and, develop in-state capacity to meet the equipment and expertise needs of the national industry.

Introduction

This memo reviews the main environmental effects of cannabis cultivation (we do not analyze processing or distribution), emphasizing energy and climate issues with a briefer review of other considerations (water use, chemicals, etc.). We find that the predominant environmental concern in marijuana production is energy use for indoor production (less importantly for greenhouse production) and in particular the climate effects of this energy use. We then turn to the main opportunities for growers to reduce these environmental consequences, finding that the most important is substituting greenhouse and outdoor production for indoor operations, and managing indoor production for reduction of electricity use and especially electricity use during the day. We also sketch some ways the Liquor Control Board (LCB) can encourage better environmental practice in this industry.

Indoor cannabis production is very energy-intensive compared to other products on a per-pound basis, less so per unit value. However, environmental risks from cannabis production are nowhere near as salient a part of the overall policy framework for marijuana as (for example) the explosive and toxic hazards of methamphetamine, or the environmental costs of large-scale agriculture, mining, metallurgy, and other industries. Nor should legal cannabis production, licensed and inspected, generate the variety or degree of environmental damage inflicted by illegal production (Barringer 2013). Our bottom line is that environmental considerations should not be a major component of marijuana policy, but are worth explicit attention and policy design.

Cannabis culture

This section briefly discusses the main methods of cannabis production, in particular growing the plants from which marijuana and other psychoactive materials are derived.

The cannabis varieties of psychoactive interest are dioecious annuals adapted to climates in the warm-temperate to subtropical range and grown primarily for the flowers of the female plant. Cultivation requirements are determined by these properties and the plant's flowering response to a prolonged diurnal dark period.

Cannabis can be grown from seed, with male and female plants separated after germination, or from cuttings (clones). Rooting clones assures an all-female stand of plants and preserves the respective use properties of the many varieties that have been developed.

The seedlings are grown to the desired size and maturity in a *vegetative phase* and induced or allowed to flower. When unfertilized flowers reach the desired size, they are harvested for further processing. Growing can be hydroponic (in water with dissolved nutrients), in soil (usually outdoors), or in an irrigated artificial growing medium for mechanical support.

Light is provided by the sun outdoors or in a greenhouse, or with electric lighting indoors or sometimes in a greenhouse. Indoor growing requires ventilation, sometimes filtered to reduce odor, to remove heat and humidity. CO_2 may be provided to accelerate growth, usually by venting a propane or natural gas flame into the plants' enclosure

Weeds may be controlled with herbicides outdoors; pests including insects, disease, and fungus may be controlled with chemicals or mitigated with design and management of growing chambers. Cannabis can be grown organically, without chemical fertilizers or pesticides, but at higher cost and usually lower yield.

The high specific value of cannabis flowers, and the desire of illegal growers to minimize and hide the area used for cultivation, has nurtured a labor-intensive, space-concentrated practice for indoor production analogous in some ways to horticulture of orchids and other delicate and exotic plants. This practice may change significantly in a legal operating environment.

Environmental consequences of cannabis production

Energy

The most significant environmental effect of cannabis production, and the one that varies most with different production practices, is energy consumption, especially fossil energy use with climate effects from release of greenhouse gas. Indoor-grown marijuana is an energy-intensive product by weight, using on the order of 2000 kWh per pound of product (for comparison, aluminum requires only about 7 kWh per pound). However, the high unit value of marijuana (approximately $2,000/lb. at wholesale[1]) compared to aluminum (~$0.90/lb)[2] means energy is a much smaller fraction of product cost: accounting for the value of the products, it takes 8,000 kWh to make $1,000 worth of aluminum vs. 1,000 kWh for $1,000 of marijuana. Glass is considered an energy-intensive product, but energy costs represent only about a sixth of glass-production costs, about half the energy-intensity of indoor-grown cannabis.

Total current marijuana consumption in Washington is estimated at about 160 metric tons per year; if this quantity were to be grown indoors with typical practices, marijuana cultivation would increase the state's electricity demand by about 0.8% (using 2010 as a baseline year). Mills estimates that California indoor cultivation currently uses 3% of all electricity in the state (note that California has higher electricity prices than Washington and lacks the electric-intensive industry cluster of the northwest) (Mills 2012). While precise estimates are impossible, ma-

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[1] The wholesale price of marijuana is highly uncertain and currently subject to significant market distortion from the illegal nature of the product. The price in a legal-market framework is likely to be lower.

[2] Based on Aluminum futures prices on the London Metals Exchange http://www.lme.com/metals/non-ferrous/aluminium/

rijuana cultivation will be a non-trivial though small component of Washington energy consumption: significant enough to be worth reducing where possible without offsetting losses on other dimensions of value.

Indoor growing

Growing marijuana indoors requires careful and energy-intensive replication of ideal outdoor conditions, including provision of light, fresh air ventilation, cooling (required due to the energy density of lighting and ventilation) and control of pests and fungal agents. Indoor growing allows high profits from the typically high-grade product that is produced under controlled conditions and is also perceived by many growers as more secure and stealthy. Indoor cultivation can also achieve multiple harvests per year; growing marijuana with electricity divorces the process from the constraints of seasonal growing and typical harvest cycles.

Figure 1: Indoor Cannabis culture

An extensive peer-reviewed study details the energy consumption of present day indoor production facilities. Lighting levels are elevated 500 times greater than (for example) recommended for reading, while ventilation occurs at 60 times the